Daniel K. Inouye Solar Telescope (DKIST)
Habitat Conservation Plan and Biological Opinion 2016 Report

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I. INTRODUCTION

This fiscal year report to the State of Hawai`i is being submitted by the Daniel K. Inouye Solar Telescope (DKIST) Resource Management Team, in accordance with the DKIST Habitat Conservation Plan (HCP) and the Final Biological Opinion (BO) of the U.S. Fish and Wildlife Service (USFWS, 1-2-2011-F-0085). The purpose of this report is to provide the collaborative primary agencies with an update on the progress and compliance of the project, as well as to summarize results of mitigation and monitoring activities being implemented for the DKIST project.

I A. The DKIST Project

The Association of Universities for Research in Astronomy (AURA) is a consortium of universities, and educational and other non-profit institutions, that operates world-class astronomical observatories, termed “centers”. AURA operates the National Solar Observatory (NSO) under a cooperative agreement with the National Science Foundation (NSF). Once AURA completes construction of DKIST, it will be the world’s premier solar telescope, with unprecedented abilities to view details of the Sun. Using adaptive optics technology, DKIST will be able to provide the sharpest views ever taken of the solar surface, which will allow scientists to learn even more about the Sun and solar- terrestrial interactions.

Construction for the telescope project began on December 1, 2012. The original name for the project was the Advanced Technology Solar Telescope (ATST) and it was renamed the Daniel K. Inouye Solar Telescope on December 15, 2013, in honor of the late Senator Daniel K. Inouye. The DKIST is located within the 18.166-acre University of Hawaiʻi Institute for Astronomy (IfA) Haleakalā High Altitude Observatory (HO) site at the summit of Haleakalā, County of Maui, Hawaiʻi. The DKIST facilities will include an approximately 136 ft. (41.5 m) tall building housing the telescope, an attached support and operations building, and a utility building.

I B. DKIST Habitat Conservation Plan (HCP) and Biological Opinion (BO)

The DKIST Habitat Conservation Plan (HCP), which was approved by the State of Hawaiʻi Board of Land and Natural Resources (BLNR) in January 2011, addresses potential impacts to state and federal threatened, endangered, and listed species during the construction of the DKIST at HO, pursuant to Chapter 195D, Hawaiʻi Revised Statutes (HRS 195D). The Biological Opinion (BO) was published on June 15, 2011 by the U.S. Fish and Wildlife Service. The species of focus in both the HCP and BO is the Hawaiian Petrel (*Pterodroma sandwichensis)*

I C. Incidental Take License and Incidental Take Statement

The State BLNR issued an Incidental Take License (ITL), No. ITL-13, to the NSF on November 30, 2011, and the USFWS issued an Incidental Take Statement in the BO to address potential take during DKIST construction. The ITL was issued with the anticipation that a level of take of as many as 35 Hawaiian Petrel individuals (30 fledglings and 5 adults) would occur, and that the conservation mitigation efforts in place will offset such take during the construction phase, where such take is incidental to and not the purpose of the carrying out of an otherwise lawful activity. Once construction of the DKIST is complete, the operations of the DKIST facility are not expected to result in incidental take of listed species under HRS 195D. The USFWS anticipated that project related harassment and indirect effects of birdstrike mortality will reduce the number of fledglings produced by Hawaiian Petrels by no more than 32.

I D. FAA/Coastguard Communication Tower Monitoring

Because of a concern that the DKIST facility may interfere with the Federal Aviation Administration's (FAA) ground-to-air signal conveyance, NSF, through AURA/NSO, funded necessary tower upgrades on two of the existing FAA Radio Communication Air to Ground (RCAG) towers located on FAA property adjacent to HO. These tower upgrades were completed on October 8, 2012. By agreement between NSF and FAA, the DKIST Resource Management Team continues to monitor the FAA tower site to collect potential petrel-tower collision information.

II. HAWAIIAN PETRELS: BACKGROUND INFORMATION

II A. Status of the Species

The Hawaiian Petrel (*Pterodroma sandwichensis*) was listed as endangered on March 11, 1967 (32 FR 4001). The species is a medium-sized seabird in the family Procellariidae (shearwaters, petrels, and fulmars). The Hawaiian Petrel was formerly treated as a subspecies of *P. phaeopygia*, with the nominate subspecies occurring in Galapagos (*P. p. phaeopygia*). However, based on differences in morphology and vocalization, the two subspecies were reclassified as full species in 1993 (Monroe and Sibley, 1993) and genetic analysis confirmed the split several years later (Browne, et al., 1997, Welch 2011).

II B. Historical and Current Distribution and Threats

Hawaiian Petrels were abundant and widely distributed in prehistory; their bones have been found in archaeological sites throughout the archipelago (Olson and James, 1982). Prior to Polynesian colonization, this species had no natural terrestrial predators other than the Hawaiian owl (Pueo, *Asio flammeus sandwichensis*). When Polynesians arrived in the archipelago, they collected petrels for food (Harrison 1990) and introduced rodents, dogs (*Canis lupus familiaris*) and pigs (*Sus scrofa domesticus*). After Captain Cook landed on the islands, the introduction of avian diseases (Warner, 1968), cats (*Felis silvestris catus*), Indian small mongoose (*Herpestes javanicus*), more rodent species and ungulates has resulted in substantial declines in the distribution and numbers of this species.

Other significant anthropogenic sources of Hawaiian Petrel mortality are light attraction and collision with communications towers, power transmission lines and poles, fences, and other structures (Simons, 1983). The Hawaiian Petrels fly at over 30 miles/hour (48 km/hour) (Day and Cooper, 1995), which likely reduces their ability to detect obstacles in the dark and avoid them. This problem is likely to be exacerbated by the continuing development and urbanization throughout Hawaiʻi.

Besides terrestrial threats, the species may be adversely affected by other factors as well. Hawaiian Petrels forage for food at the water's surface, and due to over-fishing, there are declining populations of large predatory fish that drive petrel prey species to the surface. That may affect the Hawaiian Petrels' ability to feed. In addition, it is known that the distribution of fish changes during El Niño years, when the surface water temperature rises and fish species migrate north to cooler temperatures (Bird Life International 2014, NOAA). Since the Hawaiian Petrels return to the same foraging locations each year, during El Niño years they may be feeding (themselves and their young) on less suitable fish. Additional factors such as Fukushima marine debris, radiation pollutants, and global weather pattern changes can also affect the Hawaiian Petrels' food supply, and therefore may adversely affect their ability to maintain proper sustenance.

Hawaiian Petrels are currently known to nest on at least four islands (Bird Life International 2014), but their distribution is limited to high alpine or rainforest sites where predation pressure is lower. An accurate estimate of total numbers of Hawaiian Petrels is not available; however, estimates range from the thousands to about 34,000 (e.g., Spear, et al., 1995; Ainley, et al., 1995). Spear, et al. (1995) estimated the at-sea population size of adult and sub-adult Hawaiian Petrels of 19,000 birds (with a 95 percent confidence interval of 11,000 to 34,000). Ainley, et al. (1997) estimates a breeding population of about 1,600 pairs on Kauaʻi and Ainley (USFWS, unpublished field notes) estimates that there are a few thousand pair occurring on Lanaʻi and 1,500 on Haleakalā. Darcy Hu (2009, personal communication) located 115 active burrows within the Hawaiʻi Volcanoes National Park (HAVO) in 2006. As of 2009 it was estimated that between 1,000 and 6,000 Hawaiian Petrels come to shore each year on all islands (Jay Penniman, personal communication 2009).

Although the Hawaiian Petrel still can be found on four of the eight major islands, each population is morphologically (Judge 2011), behaviorally (Judge 2011, Wiley et al. 2013) and genetically (Welch et. al. 2012) unique to other populations. Most of the unique Maui population nests along the rim of Haleakalā Crater, within Haleakalā National Park and in the vicinity of the DKIST action area. The most recent estimate of breeding petrel numbers in these areas is roughly 400 to 600 breeding pairs (Simons and Hodges, 1998; Bailey 2006, personal communication). A primary reason for the relatively large numbers of petrels and their successful breeding around Haleakalā summit today is likely due to the fencing and intensive predator control maintained by Haleakalā National Park since about 1982. Without such fencing, the petrel's habitat is destroyed or severely compromised by feral ungulates such as goats, and by pigs in wetter and more vegetated environments than the summit of Haleakalā. In addition to collapsing burrows and compacting the substrate, these animals act as vectors for invasive plants that alter the vegetation structure and may hinder the birds' access to traditional nesting areas (Simons, 1985).

The birds spend much of their time at sea where they are known to feed on squid, small fish, and crustaceans displaced to the surface by schools of tuna (Larson, 1967; Simons, 1985). Adult Hawaiian Petrels have been tracked taking single trips exceeding 6,200 mi (10,000 km) circumnavigating the north Pacific during the nesting stage (Adams & Flora, 2010), and have been recorded in the Philippines (Rabor, et al., 1970), Japan (Nakamura, 1979), the Gulf of Alaska (Bourne, 1965), and off the coast of Oregon and California (Pyle, et al., 1993).

II C. Nesting Habitat in Haleakalā

The largest known nesting colony of Hawaiian Petrels is located in and around the Haleakalā National Park (Simons and Hodges, 1998). Prior to the DKIST project, approximately 30 known burrows were located along the southeastern perimeter of HO, several burrows were northwest of HO, and additional burrows have been found northeast of the DKIST Project site (NPS, 2003).

Although historically the species may have nested at lower elevations (USFWS, 1983), the current nesting habitat of Hawaiian Petrels on Maui is at elevations above 7,200 ft. (2,195 m).

The Hawaiian Petrel nests on Haleakalā in high elevation burrows located beneath rock outcrops, under boulders and cliff faces, along talus slopes or along edges of lava flows where there is suitable soil underlying rock substrate for excavation of tunnels. Most of the nests on Haleakalā are in rock crevices in sparsely vegetated, xeric habitat (Simons and Hodges, 1998). Burrows are excavated by the petrel to a depth of 3 to 6 ft (1.0 to 1.8 m), but sometimes reach a length of 15 ft (4.6 m) or more.

The majority of known Hawaiian Petrel burrows are located along the western rim of the Haleakalā Crater, where this habitat is most abundant and also where predator control is provided. Using survey efforts from 1990-1996, previous estimates of burrow density, a portion of which included the mitigation area within HO, range from 5 to 15 burrows per hectare (ha), compared to 15 to 30 burrows per ha along the western crater rim. The difference in density may be attributed to the fact that the mitigation area had no predator control prior to 2013, and that two-thirds of the mitigation area is cinder field, which is not a suitable environment for petrel nesting. Similarly, in 2004 and 2005, Hawaiian Petrel passage rates, collected using ornithological radar, were 4 to 7 times greater during summer and fall at the Visitor’s Center (Western rim), when compared to the Haleakalā Observatory complex, suggesting bird numbers are lower in areas encompassing the DKIST mitigation site. Importantly, the population trend at Haleakalā is increasing, which suggests that additional recruitment into this site is possible (Holmes, 2010).

There are four Hawaiian Petrel burrow clusters, and a number of isolated burrows, within approximately 1,250 ft (381 m) of the DKIST Project site, totaling approximately 31 individual burrows. Burrow clusters and individual burrows to the west and the northwest of the construction site historically have not been greatly used by nesting Hawaiian Petrels (Bailey, 2009, personal communication); approximately 5 to 10 burrows (mostly inactive) are 500 to 800 ft (244 m) from the construction site that is to the west.

II D. Nesting Phenology

Hawaiian Petrels are present at Haleakalā from February through October and are absent from November through January.

Similar to other members of its family, the Hawaiian Petrel has a well-defined, highly synchronous nesting season (Simons, 1985). There is also clear evidence of intra-island variation in breeding phenology within Hawaiʻi, with Haleakalā breeders initiating, and completing, breeding approximately one month earlier than Kauaʻi, Lanaʻi, and Hawaiʻi Island. At the Haleakalā site, birds arrive in their colonies in late February. After a period of burrow maintenance and social activity they return to sea until late April when egg-laying commences. Non-breeding birds visit the colony from February until late July (Simons and Hodges, 1998). Many of these may be young birds seeking mates and prospecting for nest sites, but some percentage is thought to be mature adults that do not elect to breed.

Hawaiian Petrels are thought to begin breeding at about 5 or 6 years of age, and roughly 90 percent of breeders attempt to breed each year (Simons and Hodges, 1998). Beginning in mid-February to early March, after a winter absence from Hawaiʻi, breeding and non-breeding birds visit their nests regularly at night, for a period of social activity and burrow maintenance work. Pairs are site tenacious, returning to the same burrow year after year. From mid-March to mid-April, birds visit their burrows briefly at night on several occasions. Then breeding birds return to sea until late April or early May, when they return to lay and incubate their eggs.

Both adults participate in incubating the egg and feeding the chick; after a brief brooding period, both adults are foraging at sea and will have absences from the nest (Simons, 1985). Male and female birds alternate incubation attendance, and total incubation period ranges from 45 to 58 days (Simons, 1985). Egg temperature and evaporative water loss are controlled by the incubating adult. Because the metabolism of awake, resting birds is almost twice that of sleeping birds (Simons, 1985), disturbance of incubating birds' sleep could potentially result in more rapid weight loss and an inability of the adult to stay on the egg until its mate relieves it.

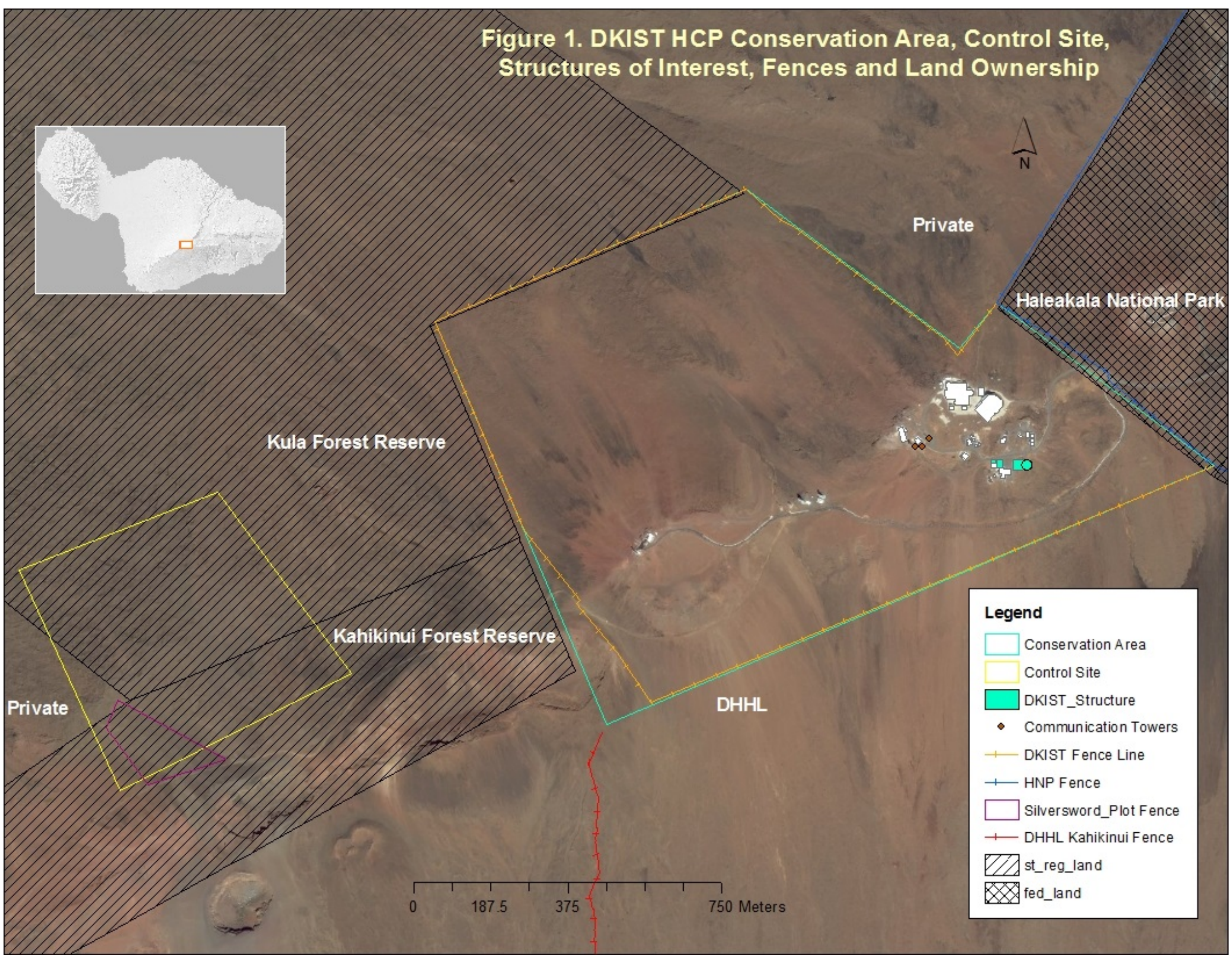
During the incubation period, many non-breeding birds also inhabit the colony. Many of these are young birds gaining experience seeking mates and prospecting for nest sites; the remaining portions are experienced breeders that did not elect to breed. Non-breeders and failed breeders typically begin leaving the colony once the eggs have hatched. The non-breeders continue to visit their burrows at night through early August (Simons, 1985). By September, the only birds visiting the colony are adults returning to feed their chicks (Simons, 1985). Chicks do not appear to require much brooding from their parents. Adults depart from the nest to forage at sea within 1 to 6 days after the chick hatches (Simons, 1985). Chicks spend 66 percent of their time alert, resting quietly, 26 percent of their time sleeping, 6 percent of their time preening or stretching, and 2 percent of their time walking around (Simons, 1985). Nocturnal feeding by one parent occurs approximately every other day until the chick is 90 days old. After 90 days, adults appear to continue to feed chicks until the chick refuses food. Chicks fledge between late September and late October, after an average of 111 days after hatching (Simons, 1985, though our data shows fledging goes into the first week of November). Although adults are occasionally observed to remain after fledglings depart, colonies generally are empty by the end of November.

A hiatus of only about three months occurs between the end of one breeding season and the beginning of the next.

III. OVERVIEW OF THE DKIST HCP CONSERVATION AREA AND CONTROL SITE

The DKIST HCP requires the establishment of a Conservation Area to mitigate the potential negative effects related to construction of the DKIST facility. In addition, the HCP also specifies the need to establish a Control Site to compare and evaluate the DKIST Resource Management Team's conservation efforts within the HCP Conservation Area. Both of these areas have been established and maintained since 2011.

The Conservation Area (Figure 1) is located between approximately 8,800 and 10,000 ft. (2,686 to 3,048 m) in elevation, and includes observatory facilities, broadcast facilities, communication towers, and the portion of Skyline Trail dividing the area from the northeast to the southwest. Adjacent lands include the Kula Forest Reserve, Kahikinui Forest Reserve, National Park Service (NPS), Department of Hawaiian Home Lands (DHHL), and private land. The conservation/mitigation site contains a number of cinder cones, of which Puʻu Kolekole is the highest in elevation. This cone is about 0.3 mi (0.5 km) from the highest point on the mountain, Puʻu ʻUlaʻula (Red Hill) Overlook, which is in the Park and outside of state land (Figure 1). Based on the State of Hawaiʻi website published TMK GIS layer, the area was estimated to be 328 acres (133 ha), however after the ground survey using existing metes and bounds was completed, it was determined the area covers an area of 321.79 acres (130.22 ha).



Note: The ground-truth DKIST HCP Conservation Area boundary on the map is different from the State of Hawaiʻi website published TMK GIS layer. The actual metes and bounds on the ground vary from the GIS layer up to 33 meters.

The annual average total precipitation on the Haleakalā summit, in the vicinity of the Conservation area, between 1949 and 2005, was 52.92 inches (in) (134 centimeters (cm). At or near the summit, sustained wind speeds of 50 miles per hour are not unusual. The peak wind speed recorded at the summit was over 125 miles (mi) per hour (201 km per hour). The topography within the Conservation Area is rugged and barren, and the elevation drops with an average slope greater than 30 percent (DKIST 2010). Temperatures at the summit of Haleakalā can range between below freezing to highs of 65°F (18°C, HALE 2011).

The Control Site (Figure 1) encompasses 80 acres and is one kilometer west of the west boundary of the Conservation Area, just north of the Skyline Trail, at an elevation of 8,700 to 9,300 ft. (2652 to 2835 m). The topography within the Control Site is similar to that of the Conservation Area.

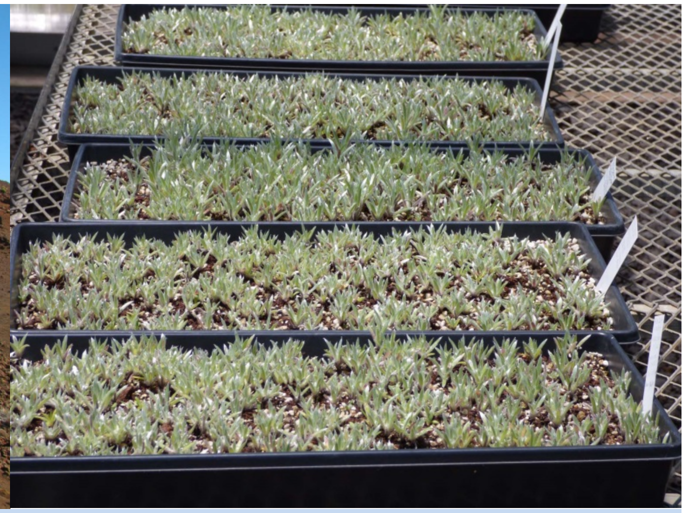
IV. DKIST HCP and BO COMPLIANCE

The DKIST team continues to meet or exceed compliance with HCP and BO required mitigation measures. Following is a summary in reverse chronological order (most recent first) highlighting the major compliances.

IV A. Silversword Outplanting and Seed Propagation: November 2014

Eight hundred seeds from four flowering Silversword plants within the DKIST Conservation Area were collected on November 18, 2014 by subcontractors Starr Environmental, under a permit issued by DLNR on November 10, 2014. The seeds were turned over to Haleakalā National Park (HALE) for propagation. In compliance with the HCP, the DKIST resource management team carefully checked the source area during its June 2015 monitoring to see if there was natural regeneration from the Silversword seed bank in the area from which the seeds were collected. The resource management team could not locate any seedlings during its June and August, 2015 monitoring, and therefore outplanting was initiated to add to the population. In total, 306 Silversword seedlings were planted on December 8, 2015 by Starr Environmental, the DKIST resource management team and one Haleakala National Park employee. Each plant was tagged with a unique numbered metal tag, and GPS coordinates and width were also recorded. Starr Environmental will conduct annual survival and growth monitoring during the next few years (Figure 2).

Silversword seed collection (DKIST in background)



Silversword propagation

View of Silversword outplanting

Another View of Silversword outplanting

Figure 2 Silversword outplanting around the area where seeds were collected in the winter of 2014.

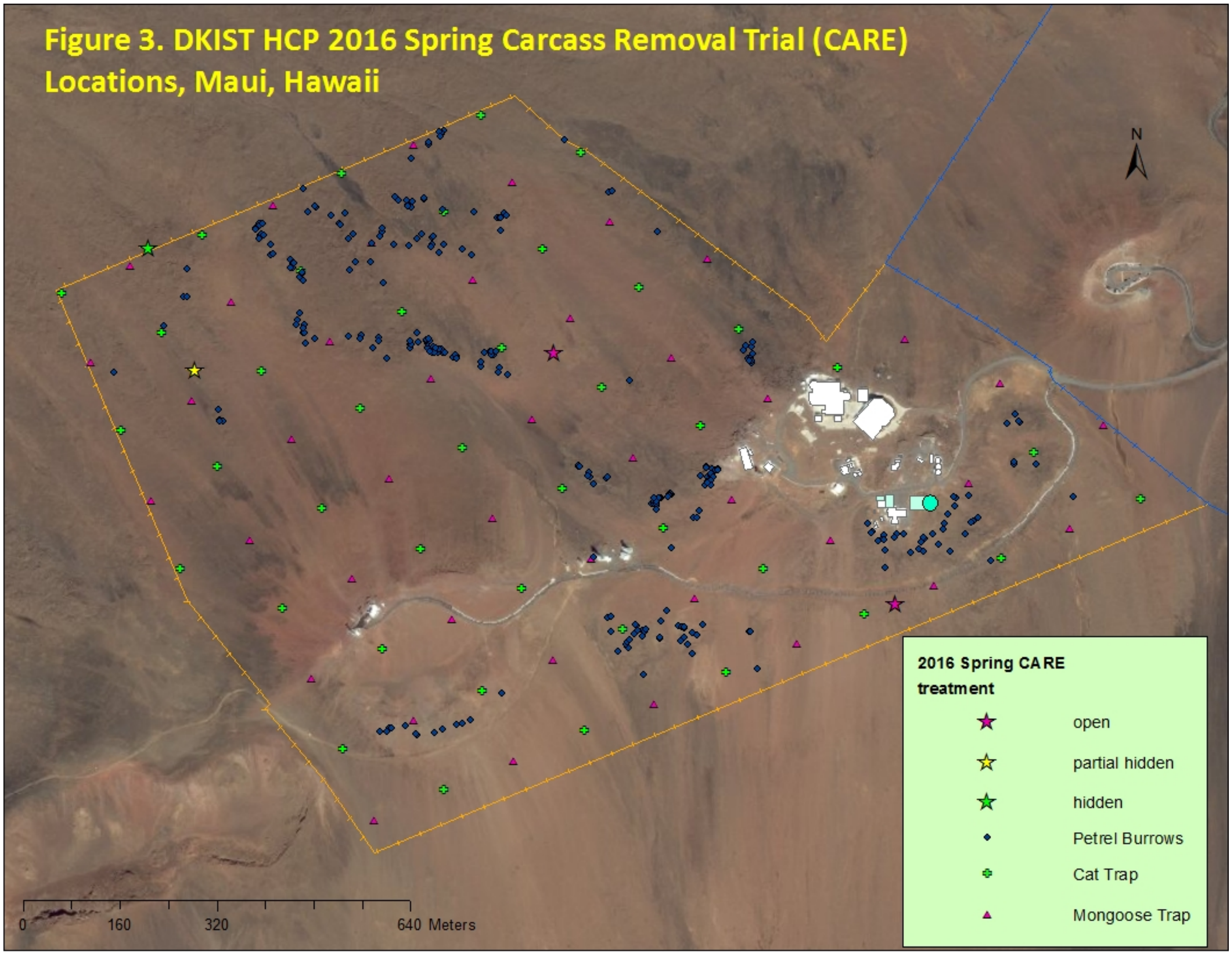
IV B. Monitoring Burrow Structures in the Impact Area: February 2015

In 2015, KC Environmental, Inc. (KCE) developed a new burrow scope with a remote directional control capacity to maneuver more easily in burrows during inspection. The burrow scope is only used during the non-breeding season to avoid risk of burrow damage. After an initial test period in 2015, routine monitoring for potential impact to burrow structures adjacent to the DKIST construction site was implemented. No damage to burrows was detected during inspections after the 2015 breeding season.

IV C. Carcass Removal Trial (CARE): Ongoing Since September 2013

Carcass Removal Trials are undertaken to determine the scavenging rate by cats, rats, mongoose or other scavengers of birds that may have been killed via birdstrike. Pursuant to adaptive management changes approved by DOFAW and USFWS for the HCP and BO on July 29, 2014, two CARE trials will be conducted each year during the remainder of the 6 year construction period. These trials are to be conducted by a third party contractor and the information will be used to guide search intervals for birdstrike monitoring for the DKIST project.

CARE trials have been conducted by KCE since the fall of 2013. Trials are conducted in locations within the DKIST Conservation Area that are approved by USFWS and DOFAW and that are at least 50 meters from a Hawaiian Petrel burrow and 30 meters from baited traps. Figure 3 is an example of surrogate bird placements (from the 2016 spring trial). Surrogate bird (Wedge Tailed Shearwater, *Puffinus pacificus*) carcasses were placed in a variety of positions, including two that were exposed (thrown), one hidden to simulate a crippled bird, and one partially hidden.



The results of the CARE trials conducted through the spring of 2016 are presented in table 1. In trials since 2013, only two birds have been partially scavenged, and even during an extended 60 day trial in the summer of 2014, all four trial carcasses remained intact after the full 60 days. The 2013 fall scavenge event occurred in a partially concealed location within two weeks of placement, with only feathers left behind, while the 2015 summer scavenge event was from a concealed location within two weeks of placement, with a partially dismembered carcass remaining. The overall scavenge rate was 0.07 (based on seven 30-day trial periods in which two of the 28 total carcasses were scavenged) and total carcass removal rate was zero as of spring 2016.

Table 1. the Outcome of DKIST HCP Carcass Removal Trial Fall of 2013 - Spring of 2016				
Year	**Season**	**Period (days)**	**% Birds Scavenged**	**Remarks**
2013	Fall	30	25	Remains still detectable at the end of the trial
2014	Spring	30	0	
2014	Summer/fall	60	0	Extended trial
2015	Spring	30	0	
2015	Summer	30	25	Remains still detectable at the end of the trial
2016	Spring	30	0	

The results of the CARE trials are consistent with the experience of the DKIST Resource Management team, in that carcass remains have been found in the Conservation Area that are often more than a year old. The CARE trials show further evidence that scavenging rates at these higher altitudes is extremely low. After six such trials (seven, if the extended trial is considered as two trials), only two surrogate bird showed any sign of scavenging.

These outcomes and corroborating field experience all continue to suggest that the 10% carcass removal rate used in the calculation of unobserved take for DKIST may be too high. Almost all carcasses are recorded in the search areas for DKIST, because the predation rate is very low, and even the rare predation that takes place does not seem to remove all evidence of bird mortality for as long as a year or more. The longevity of carcasses in the field also indicates that searches for downed birds at the elevations of the Conservation Area may not have to be as frequent as thought before evidence from these CARE trials and field experience became available. (Fein and Allan 2013b, 2014b, 2014c, 2015b, 2015c, 2016b). Based on this information, DOFAW and USFWS have modified the requirements for search frequency, which is discussed in more detail in section IV M, Birdstrike Monitoring***.***

IV D. Conservation Fence and Ungulate Eradication: <u>July 2013</u>

A Conservation District Use Permit (CDUP) for the conservation fence was issued on May 17, 2013. On July 25, 2013, Rock N H Fencing, LLC was awarded the contract to construct the conservation fence. The construction started on September 1, 2013 and was completed on November 18, 2013. A total of 4.23 km (2.63 mi) of fence was built and 126.53 ha (312.66 acres) of Conservation Area was enclosed, which included 0.66 ha (1.64 acres) of Haleakalā National Park land outside of the park fence (Figure 1, 3 & 4). To prevent bird collision with the conservation fence, three strands of Poly-tape installation was completed on March 13, 2014 in compliance with HCP and BO requirements.

As a result of the fence construction process and the intensive monitoring / conservation activities that were being implemented during the fence construction, all ungulates vacated the Conservation Area before the fence was completed. Based on footage from 10 long-term predator/ungulate monitoring camera traps and six additional ungulate monitor camera traps (Figure 4), no ungulates have been detected within the Conservation Area since September 12, 2013.

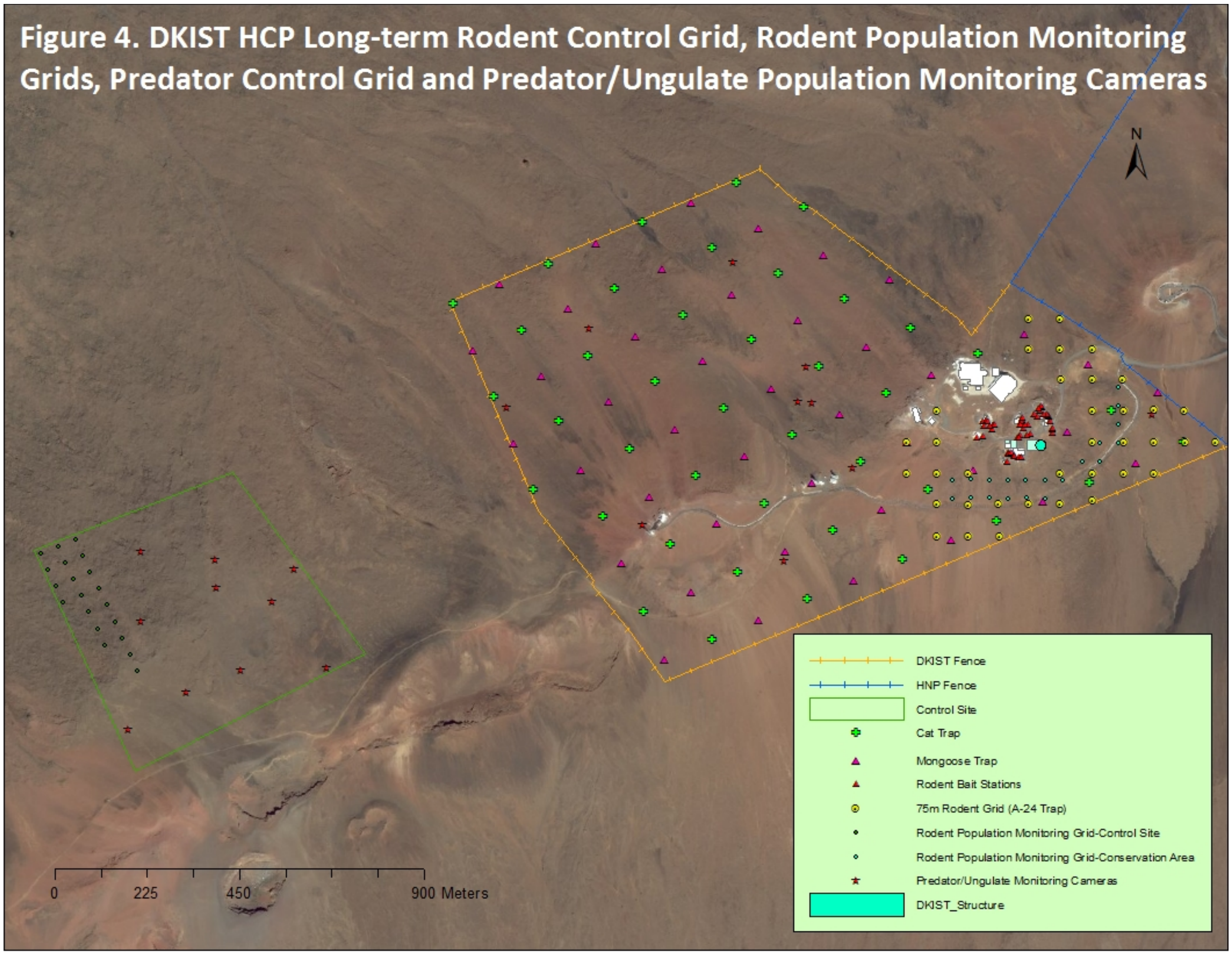


Figure 4. DKIST HCP Long-term Rodent Control Grid, Rodent Population Monitoring Grids, Predator Control Grid and Predator/Ungulate Population Monitoring Cameras

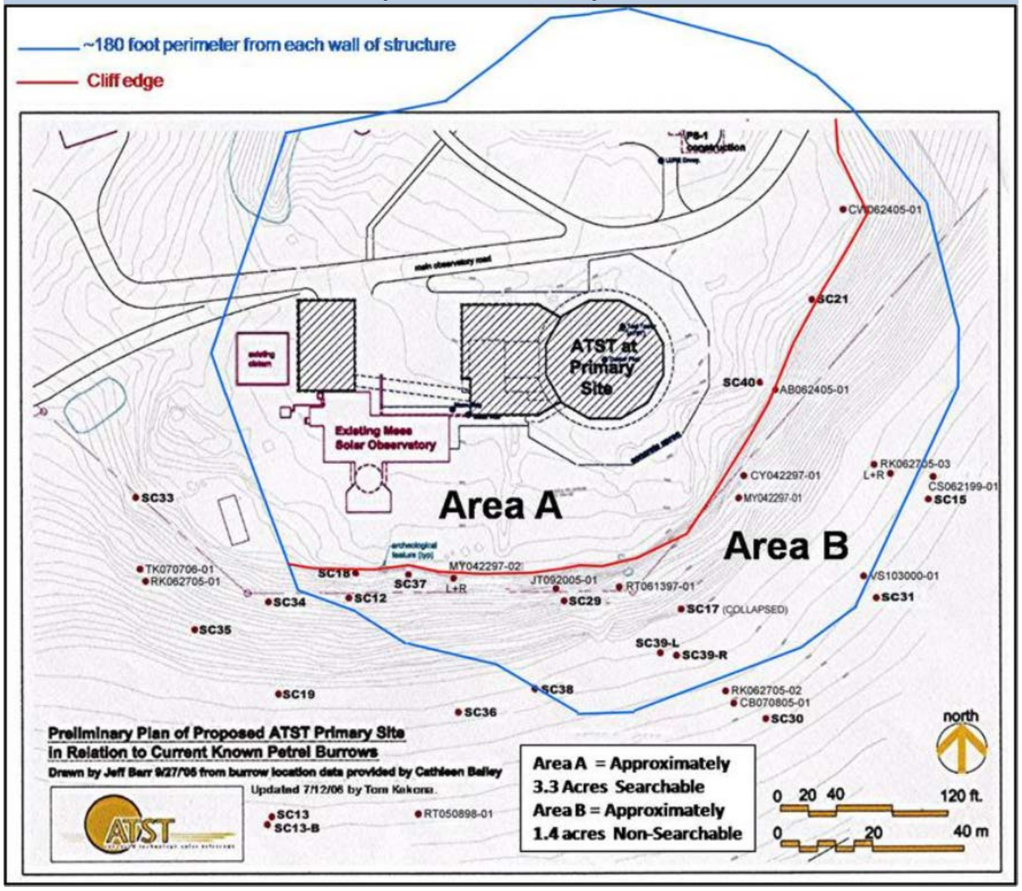
IV E. Site Boundary, Conservation Fence Line Surveying/Marking: <u>July 2013</u>

The DKIST Conservation Area (described in Section III above) boundary survey and marking was completed by Akamai Land Surveying Inc. on July 3, 2013 using the approved DKIST HCP area maps, the Hawai'i Government published GIS TMK map, and existing metes and bounds as guidance. Based on the survey, the Conservation Area covers an area of 130.22 ha (321.79 acres, Figures 1, 3 & 4). To ensure the proposed fence was within the DKIST Conservation Area boundary and to avoid disturbance of any known Hawaiian Petrel burrows and cultural resource sites, a second survey to mark the fence route was conducted on August 15, 2013 by a team including personnel from the Rock N H Fencing company, an archeologist from the International Archaeological Research Institute Inc., and the DKIST resource management team.

IV F. Searcher Efficiency Trials (SEEF): <u>Annually Since May 2013</u>

In order to accurately evaluate the overall efficiency of carcass detection in the DKIST project area, SEEF trials are to be conducted annually. Trials were conducted within the birdstrike monitoring Search Area A of DKIST's approved Conservation Area, as discussed in detail in Section IV X, and shown in Figure 5 and 7.

FIGURE 5. Demarcation of Area A and B of the DKIST Construction Site Birdstrike / Search Area. Searcher Efficiency Trials Were Only Conducted in Area A.



In accordance with the requirements of the HCP and BO, these trials are to be conducted by a third party contractor, and are to take place unbeknownst to the searcher(s). KCE was the Maui-based third party contractor selected to conduct the SEEF Trials on behalf of DKIST. In order to recover birds during the trials, the DKIST resource management team operated as a sub-permittee of KCE's Migratory Bird Permit (USFWS February 27, 2013) and Protected Wildlife Permit (DLNR March 04, 2013).

During the 8 week SEEF trials, Wedge Tailed Shearwater carcasses are used as surrogates for the petrels. Over the trial period, 20 carcasses are placed within the search area on random days and in random quantities, up to 3 carcasses per each day during which a drop was executed. After discovery, events are reported only to KCE, with photos, bird tag numbers and coordinates included in the report and the carcasses are returned to the freezer maintained by KCE at the site.

Of the 20 placed in 2013, 17 carcasses were found, resulting in a searcher efficiency rate of 85%. In the 2014 and 2015 trials, 18 of the 20 dropped carcasses were found, resulting in a searcher efficiency rate of 90% for the DKIST Resource Management team. In the most recent 2016 trial, 19 of the 20 dropped carcasses were found, resulting in a searcher efficiency rate of 95%. (Fein and Allan 2013a, 2014a, 2015a, 2016a).

IV G. Rodent and Predator Population Monitoring: <u>Ongoing Since April 2013</u>

While efforts to actually monitor rodent and predator presence are not required by the HCP or BO, the DKIST resource management team has implemented invasive mammal monitoring programs, in addition to the control program (discussed in section IV G), to help achieve Net Recovery Benefit through an adaptive management approach. Rodent population monitoring grids and predator/ungulate population monitoring camera traps in the DKIST Conservation Area and Control Site are part of these efforts.

Table 2. Rodents Caught in DKIST Rodent Monitoring Grids

Season	**Spring**		**Summer**		**Fall**		**Winter**	
2013								
Spp./location	**Control**	**Conservation**	**Control**	**Conservation**	**Control**	**Conservation**	**Control**	**Conservation**
Roof Rat	0	1	0	0	0	1	1	1
Norway Rat	0	0	0	0	0	0	0	0
Polynesian Rat	0	0	0	0	0	0	0	0
Field Mouse	0	0	1	0	1	0	0	1
Unidentifiable	0	0	0	0	0	0	0	0
2014								
Roof Rat	2	0	2	0	4	0	1	0
Norway Rat	0	0	0	3	2	0	0	0
Polynesian Rat	0	0	0	0	0	0	0	0
Field Mouse	0	0	0	0	0	3	1	0
Unidentifiable	1	0	0	0	1	0	0	0
2015								
Roof Rat	0	0	1	0	4	0	3	0
Norway Rat	0	0	0	0	0	0	0	0
Polynesian Rat	0	0	0	0	0	0	0	0
Field Mouse	0	0	1	0	3	0	1	0
Unidentifiable	0	0	0	0	0	0	0	0
2016								
Roof Rat	0	0	4	0	n/a		n/a	
Norway Rat	0	0	0	0				
Polynesian Rat	0	0	0	0				
Field Mouse	4	0	5	0				
Unidentifiable	0	0	0	0				
Remark: Control Site and Conservation Area were monitored during different dates due to adverse weather in spring of 2015.								

Using the existing Long-Term Rodent Control Grid (discussed in Section IV G), rodent monitoring involves a 48 m grid system consisting of 20 stations in the DKIST Conservation Area, and 20 stations in the Control Site (Figure 3). These two rodent population monitoring grids are 2,030 meters apart to ensure independence of the Control Site grid from the Long-Term Rodent Control Grid treatment. For this monitoring, each station was equipped with a T-Rex rat and a T-Rex mouse trap housed in Protecta tamper-resistant bait boxes. Peanut butter was used as bait and the traps were pre-baited one week before the traps were set. Each monitoring period consisted of 2 trap nights. The rodent population was monitored seasonally in March, June, September and December of each year. Table 2 summarizes the rodent monitoring results. The capture rate is low; at most only four rodents were caught during each season in each grid. The new long term rodent control grid, although not fully implemented in May 2015 (based on a plan that works around construction activity, discussed in Section IV H) appears to have reduced the rodent population in the Conservation Area even further, since no rodents were caught during the last seven monitoring periods in the Conservation Area.

Ungulate/predator population monitoring data was collected with camera traps. Twenty Bushnell Trophy Cam HD camera traps, 10 at each site (Conservation Area and Control Site), were installed at random locations generated by ArcGIS 10.0 on April 23, 2013 in the Conservation Area and on 04/24/2013 in the Control Site (Figure 4). Six additional camera traps were mounted at six selected fence posts along the fence line between December 03, 2013 and February 11, 2014, where previous goat tracks were detected. These camera traps were initially used to monitor and determine whether ungulate eradication was needed after the completion of the ungulate fence, and continue to be utilized to obtain predator population data. Table 3 summarizes the number of photos for different animal categories recorded in the camera traps. No goats were recorded in 2014 and 2015, and all human photos were images of DKIST resource management team personnel. Total numbers of animals (goats, birds and rodents) captured in photos seemed to peak in 2014 and declined in 2015 and 2016.

Table 3. Number of Pictures of Different Identifiable Animal Categories Captured by DKIST HCP Monitoring Camera Traps.

Site	*Year*	Goat	Bird[2]	*Rodent*[3]	*Human*[4]
Control	2013[1]	476	3	*0*	*1*
	2014	938	39	*6*	*0*
	2015	485	23	0	0
	2016[5]	113	15	0	0
Conservation	2013[1]	61	11	*0*	*6*
	2014	0	29	*1*	*29*
	2015	0	16	0	16
	2016[5]	0	10	0	9

1: initiated in April
2: mostly Chukars (*Alectoris chukar*), few Kolea: Pacific Golden Plovers (*Pluvialis fulva*)
3: unidentified rodent species
4: including DKIST personnel
5: date collected between 01/01-06/30/2016

IV H. Long-term Rodent Control Grid: <u>Ongoing Since March 2013</u>

In order to meet the minimum pesticide product Special Local Need Supplemental Label (SLN) label requirements, a 50 meter grid layout plan was initially submitted to the agencies by the DKIST team. However, after consultations with USFWS, it was agreed that the project would implement a denser 48-meter bait box grid of 51 stations. The newer 48 meter grid layout plan was approved by USFWS in March 2013, and the implementation of the grid was completed April 2, 2013.

Each station is equipped with a Protecta ™ tamper-resistant rat bait box and a mouse box. Due to the ongoing DKIST construction activities taking place on site, only 44 of the planned 51 stations were in place as of this report. Each rat bait box was deployed with eight 1-oz Ramik™ diphacinone blocks, for a total of 22 lbs. of diphacinone. The stations were checked after 1 week and then again in 2 weeks to evaluate the diphacinone take. However, the diphacinone SLN label expired on May 30, 2013, and the use of diphacinone had to be discontinued. The blocks were removed May 28, 2013. T-Rex rat and mouse snap traps baited with peanut butter have been deployed subsequently.

Resulting data from the diphacinone grid implemented from April 2, 2013 to May 28, 2013 showed only 6.6 oz. of diphacinone bait was taken. The snap traps used for the remainder of 2013 removed 18 field mice (*Mus musculus*), 10 roof rats (*Rattus rattus*) and 2 unidentifiable rats (*Rattus spp*.). In 2014, 20 field mice, 8 Norwegian Rats (Rattus norvegicus), 2 roof rats and 12 unidentifiable rats were caught prior to November 4.

The requirements under the new SLN label published in December 2013 prohibited future diphacinone use in the Conservation Area due to boundary issues, because the label calls for the grid to be extended 225 meters past the resource to be protected, which for the Conservation Area would cross the neighboring boundaries of Haleakalā National Park, the U. S. Air Force, and Department of Hawaiian Homelands. The DKIST resource management team worked closely with USFWS and DOFAW to develop a new long-term rodent control grid methodology that is not regulated by an SLN label.

A total of 47 Protecta ™ tamper-resistant rat bait boxes were placed every 30 ft. along the perimeter of all permanent structures and trailers (office, storage) within HO, except the US Air Force compound and areas affected by construction activities. For 40 ft trailers/containers, two boxes were placed, each at diagonal corners, and for 20 ft or shorter trailers/containers, one box was placed. Because diphacinone is not regulated by an SLN label for use next to buildings, each rat bait box was deployed with six 1-oz Ramik™ diphacinone blocks, for a total of 17.6 lbs. We began installing the boxes on April 30, 2015 and completed the installation on May 07 2015. More boxes will be installed once remaining minor DKIST external construction activities are completed, in order to further reduce the risk of introducing rodents due to these residual construction activities. Outside of the construction area, we began installing a 75 meter A-24 rodent killing trap grid on May 12, 2015 and completed the grid on May 18, 2015. A total of 35 A-24 traps were installed. A 25 meter A-24 trap system will be installed around HO buildings once all remaining DKIST external construction activities are completed (Figure 4).

IV I. Noise and Vibration Monitoring: <u>Ongoing Since December 2012</u>

Hawaiian Petrel burrows nearest to construction are monitored for vibration and noise to ensure the agreed upon thresholds documented in the HCP and BO are not exceeded during ground disturbing construction activities. Noise and vibration monitoring of the construction site is conducted by a third party, KCE, and has been underway since December 1, 2012, the first day of construction.

To measure vibration, measuring stations can be equipped with seismometers; depending on the location of the vibration source, one or more of six measuring stations are used to monitor ground disturbance. Two seismometers have been consistently deployed at the two burrows nearest to construction (station 4 and 6 on Figure 6). As required by the HCP and BO, noise producing activity is also monitored at the closest burrow to the construction footprint (SC-40 at map station 4, Figure 6); both at the burrow entrance, and at a distance of 5 meters from the burrow. The data from ongoing vibration monitoring shows that as of this report no construction activity during the three and half years of measurements resulted in vibration meeting or exceeding the threshold of 0.12 in/sec.

Most often, noise has not been above ambient wind levels at the burrow entrances, which can range up to 70+ dBA. KCE reported that noise levels at the burrow entrance have averaged about 56 dBA during construction, and actually decreased by about 10 dBA 5 meters closer to the source of construction. KCE explained that this decrease in noise closer to the construction can be attributed to the location of the burrow entrance being at the edge of a cliff, and often the strong trade winds at those locations induce more noise than the construction activities (due to a Venturi-like effect of higher wind speeds).

Most external construction was completed as of early March of 2016, and therefore, as of March 7, 2016 USFWS and DOFAW have agreed that during the period of interior construction noise and vibration monitoring is not necessary at the DKIST site except when large, noisy, or earth-moving operations resume.

IV J. Predator Control: <u>Ongoing Since September 2012</u>

Examination of footage from surveillance cameras in September 2012, identified the presence of a feral cat below the Mees Observatory. Camera footage revealed that the feral cat had visited five different burrows and entered at least one. A Havahart trap was set near burrow SC37 on September 13, 2012 just below the Mees Observatory. Friskies brand cat food was used as bait. The trap was labeled (CT001) along with the GPS coordinates of the trap location. The cat was captured and removed from the site.

After consulting with USFWS, a 125-meter Predator control grid system was installed consisting of 18 Havahart traps (for cats) and 19 A-24 automatic traps (New Zealand Goodnature Company, for mongoose) that cover the northern part (the lower portion with higher risk of predation) of the Conservation Area. This grid is not as uniform as it appears in plan - in the actual on-ground layout of the grid; traps were not placed within 50 meters of any known petrel burrow to avoid attracting predators into petrel colonies. Each Havahart trap was equipped with a Telonics TBT-600NH or 503-1 trapsite transmitter to allow the traps to be monitored at least every other day to avoid petrel by-catch and to ensure the welfare of the trapped animals. The installation of the northern trap grid was completed on September 16, 2013, and was operational until November 18, 2013, when all known petrels left the Conservation Area.

In order to improve the predator control efficiency, USFWS predator control experts recommended that the project employ a more unified predator control grid system. Based on this recommendation, the DKIST resource management team installed 22 additional cat traps and 23 new mongoose traps, and relocated the traps in the northern half in 2014. The new grid of 40 cat traps and 42 A-24 mongoose traps was completed on June 19, 2014 (Figure 4).

Peanut butter was used as bait in the A24 mongoose traps at first. Using this bait, the A-24 traps killed three roof rats but no mongoose. In an attempt to better lure mongoose, a change to utilize predator-specific bait was initiated on July 24, 2014, starting with cod liver oil and then changing monthly to include salmon oil, synthetic cat nip oil, and then moving to meat-based “Violator 7” and “Feline fix” products. However, after these changes from the peanut butter bait, no additional predators were caught in these traps.

The predator control traps are baited for use during the first week of February of each year and decommissioned when the last known petrel departs from the colony in late October to mid-November each year until the next petrel season begins.

In 2014, the Havahart traps caught two roof rats and no cats. As of this report nothing has been caught in the grid as of the end of June 2016.

IV K. Control Site Selection and Setup: <u>September 2011</u>

As discussed in Section III, in order to fulfill the monitoring obligations of the HCP and BO, a Control Site was selected in 2011 based on GIS research and the DKIST resource management team's ground search data in the Haleakalā summit area (Figure 1). A DLNR Permit for Access was issued on May 31, 2012 in order to conduct monitoring activities in this area, and the permit is renewed each year.

IV L. Hawaiian Petrel Burrow/Reproductive Success Monitoring: <u>Since June 2011</u>

Hawaiian Petrel burrow/reproductive success monitoring has been conducted annually since the 2011 breeding season by DKIST's resource management team, in both the Conservation Area and Control Site (Figure 1).

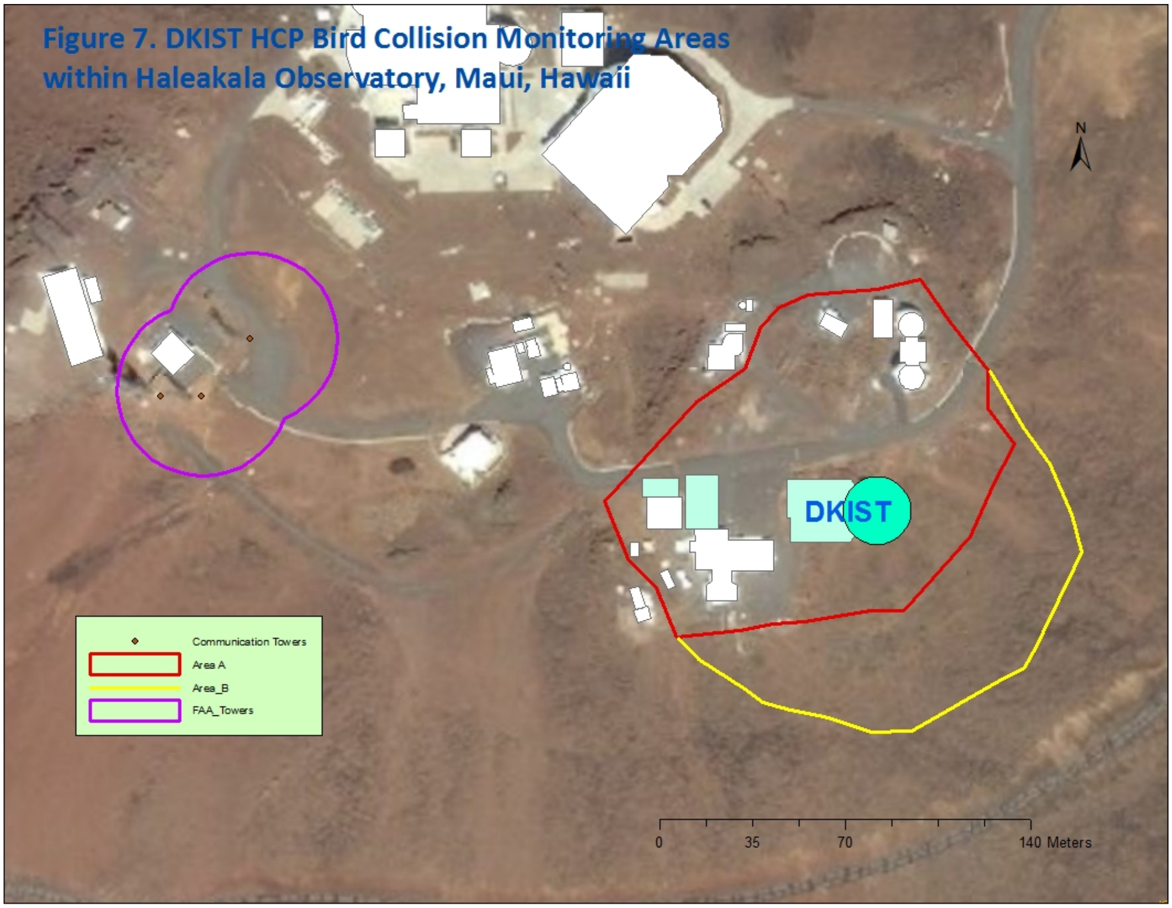
The new burrow scope that is now in use at DKIST is capable of detecting damage to burrow walls or features that may indicate collapse has occurred after nesting season. However, due to the acute angle shapes of petrel burrows and the volcanic rock, utilizing a burrow scope in the Haleakalā summit area to accurately observe eggs within burrows without risk of damage to them has not been feasible to-date. Therefore, data on the number of petrel pairs that laid eggs is not available, and for the purpose of this report, "fledgling success" is being used as a measurement of reproductive success in this area. This issue was discussed with USFWS and DOFAW on February 25, 2014 and September 25, 2014. As a result, DOFAW (October 20, 2014) and USFWS (October 30, 2014) issued letters confirming acceptance of this adaptive management approach.

IV M. Birdstrike Monitoring: <u>Ongoing Since June 2011</u>

In 2011 birdstrike monitoring took place from June 7 to November 30. Monitoring was conducted between February 1 and November 30 in 2012 and 2013. From 2014 and thereafter, the monitoring period ended on October 31, as required by the HCP and BO.

In 2011 and 2012, prior to the start of construction of the DKIST, only the two FAA communication towers were monitored. An area equal to a 75-ft. radius of the FAA towers (Figure 7) was delineated, and this radius is 1.25 x the height of the two FAA towers (60 ft.). The site was monitored every morning, seven days a week from June 7, 2011 to the second week of March 2014. Since 2014 monitoring has been conducted twice a week (primarily on Mondays and Thursdays) to reflect the HCP and BO required frequency.

Since 2013, HO search areas A and B have been monitored (Figure 7). The perimeter boundary of Area A and B is approximately 1.25 x the height of the DKIST observatory (136 ft.) extending from the perimeter of the DKIST observatory site. DKIST resource management team members conducted birdstrike monitoring within these two sites. Due to the cultural sensitivity of the summit area, no additional transect marking is appropriate; therefore, the resource management team uses only existing landmarks to mark search routes and systematically search these two sites. During the search, the team systematically searched Area A twice and scanned Area B once. When conducting the second search, the crew swaps their positions in the formation to increase the probability of detecting downed birds.



- Area A (3.3 acres (1.3 ha)): Lies on the more level area of Kolekole cinder cone and includes other observatories. This area includes roads, pathways, and roofs of buildings, plus open rocky habitat with little obstruction for detecting bird carcasses. No restriction within this search area exists, and all monitoring of Area A is done by systematic foot search.
- Area B (1.4 acres (0.6 ha)): Lies on the steep slopes south and east below the relatively flat area of Area A in an existing Hawaiian Petrel habitat. As instructed in the HCP, monitoring of Area B is conducted via use of binoculars to scan through the areas, since frequent monitoring by foot search is discouraged. Foot traffic could degrade breeding habitat in that area. Searchers are able to access the edge of the cliff at the demarcation between Area A and Area B for visual scanning (binocular-assisted) of Area B. However, because Area B includes rocks and boulders of various sizes that would obstruct simple observation of bird carcasses, it cannot be covered adequately enough to accurately count downed birds. Visual scanning, however, is useful in detecting and recovering any downed birds in the open, so that they do not become a predator attraction.

In 2014, monitoring of the conservation fence (Figure 1) was conducted twice a week until July 5. On July 6, 2014, USFWS notified the DKIST resource management team that such monitoring could be reduced to once every other week. An adaptive management amendment to the BO to confirm the change was issued on July 29, 2014. On September 23, 2014 the monitoring schedule was again amended to once each month from February to October, because the extended two-month CARE trial identified no predation. The USFWS was satisfied that fence monitoring once each month is adequate to recover any downed birds.

No petrel collisions were recorded during all the monitoring periods from 2011 to June 30, 2016 at the DKIST construction site (Area A & B), the FAA/Coast Guard towers, or along the conservation fence.

However, if any collisions were to occur, the protocol requires recording the following information: date, time, location coordinates, species, photo of the bird in question, and person attending. This information would be included in a report that would be forwarded to the USFWS, Pacific Islands Fish and Wildlife Office, USFWS Office of Law Enforcement, and DOFAW. In accordance with the protocol, the downed birds or carcasses would be handled according to the official State of Hawai'i Downed Wildlife and the USGS Wildlife Health Center, Honolulu office protocols, and if still alive, injured individuals would be delivered to appropriate local Maui veterinarians. DKIST would fund any acute care and the transport of the bird, if necessary, to a permitted wildlife rehabilitation center (currently located on O'ahu and the island of Hawai'i).

IV N. Resource Biologist/Team: June 2011-Present

DKIST Resource Biologist, Huisheng Chen, was hired on June 1, 2011. The resource management team was formed on August 8, 2011, which included the hiring of three seasonal technicians. The resource management team consisted of the same Resource Biologist along with three seasonal technicians during 2015 / 2016.

V. HAWAIIAN PETREL REPRODUCTIVE SUCCESS MONITORING: METHODS

V A. Personnel Training

All current members of the DKIST Resource Management Team received extensive training in 2011. This training included both field and administrative training. Members were trained on petrel carcass search and handling, petrel burrow identification, classification of burrow status based on signs of petrel activity, and avoidance of cultural resources during field work. In addition, the Predator Control Technician is certified for Commercial Applicators of Restricted Pesticides and each member was trained in handling rodenticide and rodent carcasses. Two of the team members were either State of Hawai'i Hunter Education certified or National Rifle Association (NRA) firearm certified. All members were previously trained in the use of GPS and ArcGIS software and all completed First Aid/First Responder and CPR certifications.

V B. Petrel Burrow Search

The DKIST Resource Management Team began monitoring known burrows and searching for new burrows in the Conservation Area and Control site on August 10, 2011, February 22, 2012. Based on experience and data collected during 2012, we realized that starting burrow monitoring in late February is likely to result in an inaccurate, overestimate of the number of active burrows, because petrels returning at this time of the year are just prospecting and forming pairing bonds, so multiple possible burrow sites might be visited by each pair. We changed our burrow monitoring starting date to better coincide with the start of nesting season in the first part of May in 2013 (May 7, 2013, May 7, 2014, May 19, 2015 and April 14, 2016). Monitoring ends each season after the petrel chick from the last known burrow fledges, which was November 16, 2011, November 10, 2012, October 24, 2013, November 11, 2014 and November 16, 2015.

The team begins annual monitoring by visiting all the burrows that were recorded from previous breeding seasons. Any newly identified burrows are documented as they are discovered and a systematic search of the DKIST Conservation Area and Control Site is also conducted. Newly identified burrows can either be a previously undiscovered burrow, or a newly excavated burrow. The DKIST resource management team utilizes recorded information provided by the Park regarding established burrows that were confirmed prior to 2011. In order to avoid mislabeling some of the thousands of rock crevices within the Conservation Area as new burrows, a structural feature isn't officially documented as a 'burrow' until its use is established by some evidence of petrel activity. When DKIST began monitoring in 2011, the same burrow identification system was continued from earlier, Park convention. That is, coordinates of the newly identified burrows are recorded with handheld Garmin Oregon 450 and 550 GPS units. Signs of petrel activity (feathers, droppings, egg shells, footprints, regurgitation, odor and other body parts) and GPS coordinates at each burrow are recorded. Toothpicks are placed vertically along the entrance of each burrow to monitor petrel movement in and out of burrows; fallen or height-altered toothpicks suggest current activity, while undisturbed toothpicks denote no activity (Hodges 1994, Hodges & Nagata 2001).

V C. Principles of Reproductive Success Monitoring

Breeding success was classified based initially on signs at the entrance, status of placed toothpicks, and the latest date of activity. Burrows that were classified as "Active" were then re-checked weekly until signs of success or non-productivity were observed. Using the same methodology as employed by the Haleakalā National Park (Hodges 1994, Hodges & Nagata 2001), a burrow was defined to be "successful" by the presence of petrel chick down feathers at the burrow entrance, and disturbed toothpicks after mid -September of each year. Burrows classified as "non-productive" showed signs of activity during initial search, but no further signs were found while conducting the subsequent re-checks, suggesting that these burrows were either occupied by non-breeders, the nest was abandoned, or the chicks did not reach fledgling age.

V D. Camera Monitoring of Reproductive Success

To establish a baseline for petrel behaviors and burrow activity near the DKIST site in the years before construction, and to supplement means of monitoring reproductive success after construction began, cable surveillance video cameras were installed and monitored by KCE every year since 2006 at burrows adjacent to the Mees Observatory, from February until all petrels left the monitored burrows.

In addition, the DKIST resource management team installed 16 Bushnell "Trophy Cam HD™" camera traps between October 15 and November 07, 2013 at 16 active burrows outside of the cable accessible area (all in the Conservation Area), and 39 camera traps were installed between September 10 and November 11, 2014, at active burrows outside of the cable accessible area; 38 in the Conservation Area and one in the Control Site. In 2015, 35 camera traps were installed in the Conservation Area and two were installed in the Control Site between September 08 and November 18, 2015. We are still intensively monitoring the burrows to determine how many camera traps will be needed to monitor 2016 reproductive success.

VI. HAWAIIAN PETREL REPRODUCTIVE SUCCESS MONITORING: RESULTS AND DISCUSSION

VI A. Number of Petrel Burrows:

Table 4 summarizes the adjusted number of Hawaiian Petrel burrows recorded within DKIST monitoring areas in the past five seasons. As new burrows were located each year, the number of burrows monitored increased from 229 in 2011 to 358 as of June 30, 2016.

Table 4. Hawaiian Petrel Burrows Found* in the DKIST HCP Conservation Area and Control Site on Haleakalā, Maui, Hawaii.

Year	2011		2012		2013		2014		2015		2016***	
Area/Status	New	Old	New	Old	New	Old	New	Old	New	Old	New	Old
Conservation Area	117	91	22	259	6	281	8	287	16	295	16	311
Control Site	21	0**	4	21	1	25	3	26	2	29	0	31
Total	229		306		313		324		342		358	

*Due to the newly marked boundary, the numbers of burrows included in our monitoring results varied annually before the conservation fence was built in 2013. In addition, two Conservation Area burrows were found to be the entrances of two other burrows in 2014. The data shown reflects the adjusted status.
**New site that year.
***Data collected 01/01-06/30/2016

VI B. Burrow Status

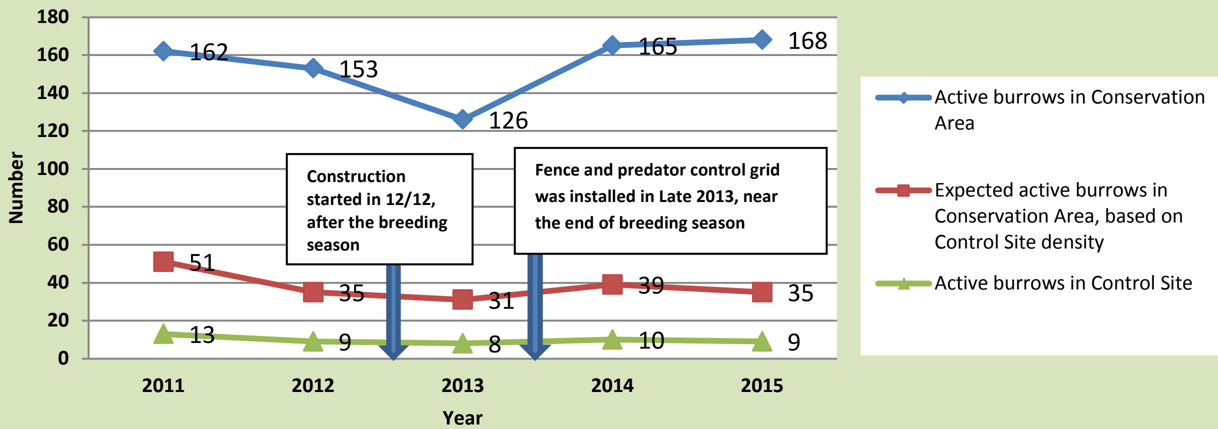
Based on monitoring data, Hawaiian Petrel burrows were classified as "Active", "Not Active" and "Not a Burrow" (burrows that were active in at least one of the previous seasons, but for which the burrow passage is no longer present in the current season). In the analysis, only burrows that were inside the boundary were included. "Nesting Activity %" is the product of the Number of "Active" burrows divided by the total number of burrows monitored that year, while "Nesting Success %" is calculated by dividing the "successful" number of burrows by the number of "Active" burrows.

Table 5. Hawaiian Petrel Burrows and Reproductive Success in DKIST HCP Conservation Area and Control Site on Haleakalā, Maui, Hawaii (Cons.=Conservation Area, Cont.=Control Site).

Year	2011		2012		2013		2014		2015		2016	
Status/Site	Cons.	Cont.	Cons.	Cont.	Cons.	Cont.	Cons.	Cont.	Cons.	Cont.	Cons.	Cont.
Active	162	13	153	9	126	8	165	10	168	9	n/a	
Successful	33	0	16	0	27	0	44	1	29	2		
Non Productive	129	13	137	9	99	8	121	9	139	7		
Not Active	36	8	114	16	155	18	128	19	143	22		
TOTAL	198	21	267	25	281	26	293	29	311	31		
Nesting Activity %	82	62	57	36	45	31	56	34	54	29		
Nesting Success %	20.24	0	10.39	0	21.43	0	26.67	10	17.26	22.22		

Table 5 summarizes the adjusted status of burrows found between 2011 and 2015, along with success/non-productive statistics. In the Conservation Area the active burrow number continued an increasing trend from the time the area was fenced in the fall of 2013. Active burrows increased to 168 from 126, which is also the largest since the project started in 2011. However, the "Nesting Activity %" of 54% was similar to 2014 (56%, $\chi 2$ =0.093, P=0.76, df=1, based on 324 burrows monitored in 2014 and 342 burrows monitored in 2015). The "Nesting Success %" of 17.26% in 2015 was the lowest since the Conservation Area was fenced, but was not statistically different from 2014 (26.67%, χ^2 =2.757, P=0.097, df=1). Data for the 2016 nesting season will be presented at the end of the year.

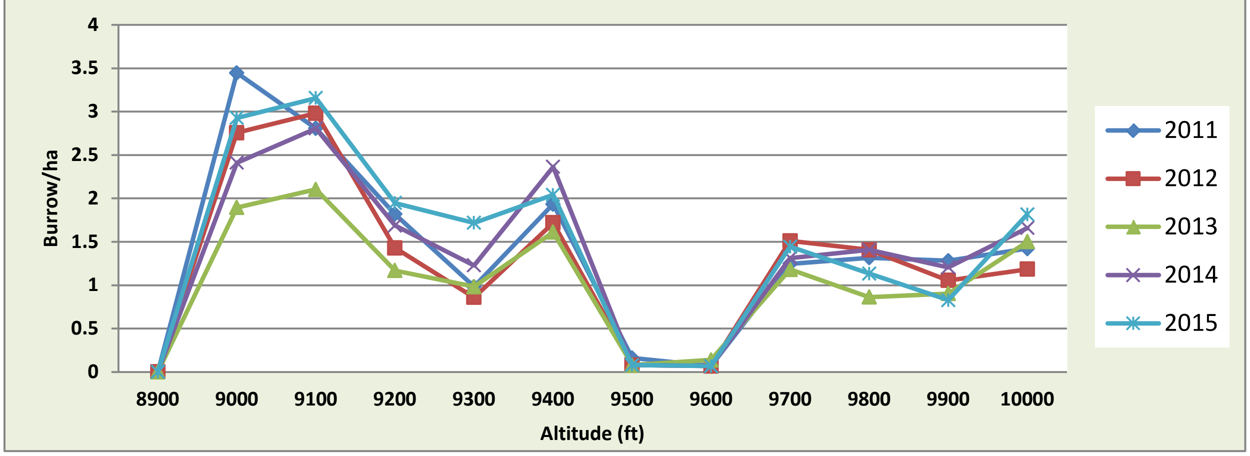
Figure 8. Active Hawaiian Petrel Burrow Numbers Recorded in DKIST HCP Monitored Areas on the Summit of Haleakala, Maui from 2011 to 2015



Density of active petrel burrows recorded from 2011 to 2014 in the Control Site (80 acres) was used to predict the number of active petrel burrows in the Conservation Area (312.66 acres). It was found that more active petrel burrows (3- 4 X more) were recorded in the Conservation Area than expected from 2011 to 2015, even in the years prior to the installation of the conservation fence and predator/rodent grids (Figure 8). This phenomenon might be explained by relatively lower petrel nesting habitat quality found or less suitable burrowing sites located in the Control Site.

Upon examination of the density distribution of active petrel burrow within the Conservation Area in different years and at different elevations, almost identical density distribution patterns in different years can be observed. The biggest deviation is observed between elevations of 8,900 and 9,100 ft., near the bottom of the Conservation Area, where predators from lower elevations have been observed. An uninhabited zone between the 9,400 and 9,600 ft. elevation levels (Figure 9) was also observed. Figure 8 also shows that petrel burrows in the HCP monitored areas are inconsistently distributed, e.g., neither evenly nor randomly distributed. Further investigation of the active burrow distribution indicates that burrows are located in lava rock areas and that cinder areas are vacant of petrel burrows. This 27 ha area between the 9,400 and 9,600 ft. elevation could be selected for artificial burrow/social attraction sites to accommodate a new petrel population, if such conservation approaches are needed in the future.

Figure 9. Active Hawaiian Petrel Burrow Density at Different Altitudes Recorded from 2011 to 2015 in the DKIST Conservation Area Near the Summit of Haleakala, Maui



Based on recent genetic and isotope studies (Judge 2011, Welch et. al. 2012, Wiley et al. 2013), the DKIST resource management team assumes that all Hawaiian Petrel colonies on the summit of Haleakalā, Maui form a meta-population. We speculate that petrels from these colonies forage in the same foraging area, and experience the same survival conditions and challenges during the same year. Intra-year comparisons between the Conservation Area and Control Site are examined and presented in order to reduce the uncontrollable effects of inter-year environmental variances; e.g. prey population fluctuation due to yearly climate, pollution, fishery pressure, prey accessibility due to debris, and declined predatory fish population to Hawaiian Petrel reproductive performance, adult/chick survival rate, and young recruitment.

We have attempted to compare trends of active burrow numbers and successful burrow numbers between the Conservation Area and Control Site, to evaluate whether the DKIST conservation fence and predator/rodent control grids have promoted recovery for the Hawaiian Petrel in the Conservation Area. The sample size of active/successful burrows recorded in the Control Site from 2011 to 2015 was too small to conduct appropriate statistical comparisons. Even population trends are difficult to identify due to the small sample size in the Control Site. For example, in 2015 the 22.2%"Nesting Success %" in the Control Site is higher than in the Conservation Area (17.2%), but the statistic is only based on nine active burrows (Table 5, Figure 10). After the first burrow successfully fledged a chick in the Control Site in 2014, two petrel burrows produced fledglings in 2015. Once again, successive years of data will shed more light on reproductive success within the Control Site.

Figure 10. Hawaiian Petrel Nesting Success % Recorded in DKIST Monitored Areas Near the Summit of Haleakala, Maui, From 2011 to 2015

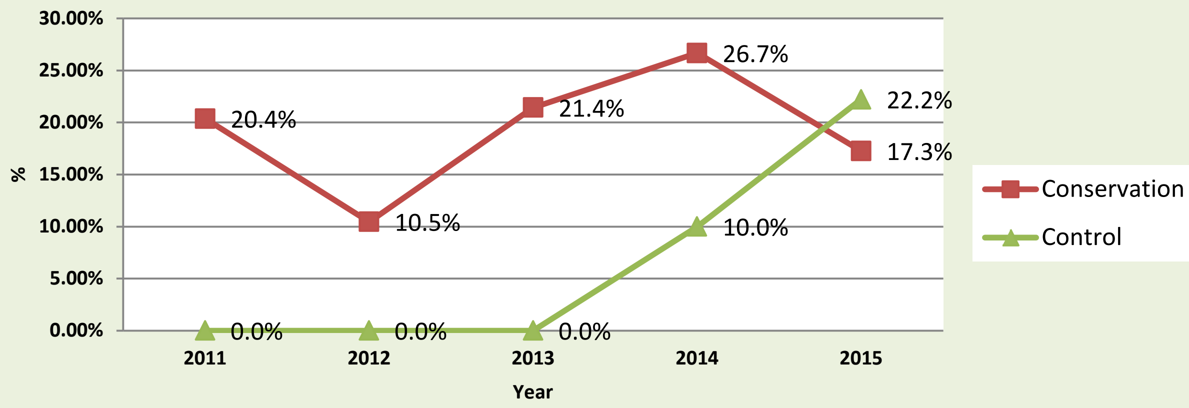


Figure 11. Hawaiian Petrel Nesting Success % at Different Altitudes Recorded Between 2011 and 2015 in DKIST Conservation Area, Near the Summit of Haleakala, Maui

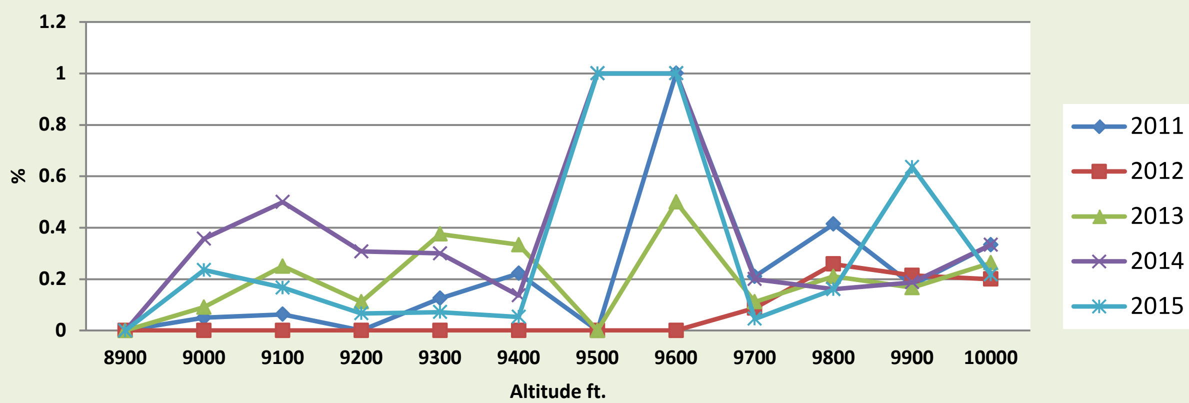
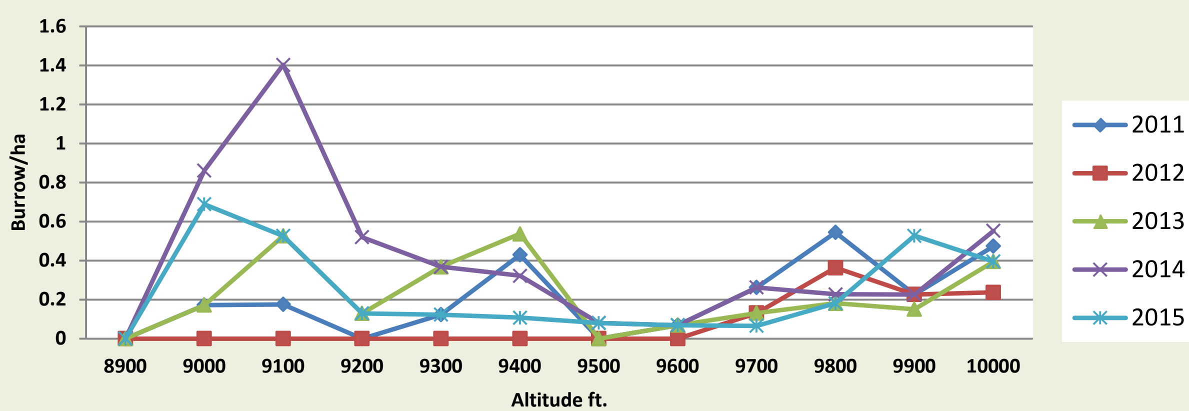


Figure 12. Successful Hawaiian Petrel Density at Different Altitudes Recorded Between 2011 and 2015 in DKIST Conservation Area, near the Summit of Haleakala, Maui



VI C. Hawaiian Petrel Mortality

Table 6 summarizes all known mortality events recorded between the 2011 and 2016 breeding seasons (as of June 30, 2016). Invasive mammalian predators were the cause of 50% of all detected petrel mortality in the DKIST Conservation Area prior to June 30, 2016. It should be noted that Control Site predation diminished more quickly than in the Conservation Area during the period from 2011 to 2015. However, since the Conservation Area is four times larger than the Control Site, and if we factor in burrow density as well, predation in the Conservation Area actually diminished more than in the Control Site.

Table 6. Known Hawaiian Petrel Mortality Events Recorded between 2011 and 2016 in the DKIST Conservation Area and Control Site

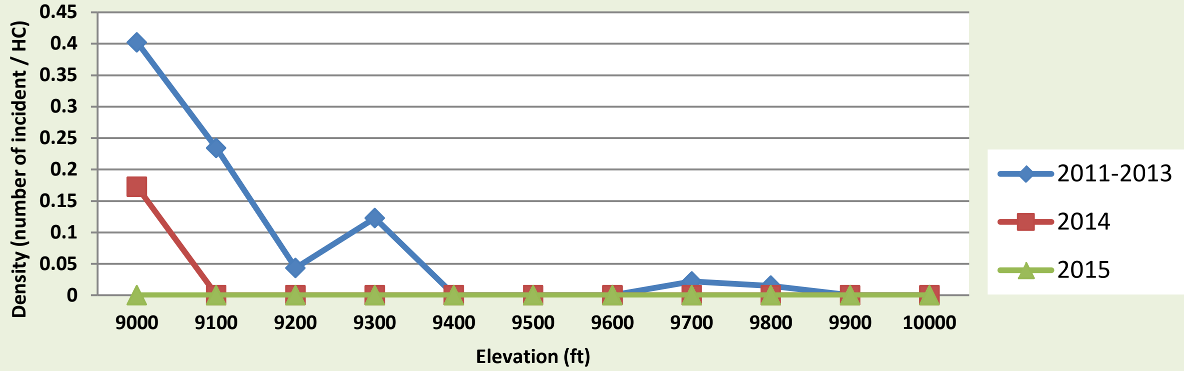
Year	2011		2012		2013*		2014**		2015		2016***	
Age/Site	Conservation	Control	Conservation	Control	Conservation	Control	Conservation	Control	Conservation	Control	Conservation	Control
Other												
Egg	4	0	1	0	1	0	2	0	14	1	0	0
Chick	2	0	0	0	2	0	1	0	0	0	0	0
Adult	1	0	0	0	3	0	0	0	2	0	0	0
Predation/burrow trampling												
Egg	1	0	2	0	0	0	0	1	0	0	0	0
Chick	6	3	1	0	3	0	0	0	0	1	0	0
Adult	1	9	3	1	0	0	1	0	0	0	1	0
TOTAL	15	12	7	1	9	0	4	1	16	2	1	0

*** Not including a burrow trampled by ungulates in the early stage of breeding season, and an adult and a chick mortality event that occurred prior to 2013.**
****** Not **including one burrow collapse in each site due to an unknown cause and consequence in early stage of breeding season. The collapsed burrow in Conservation Area was 210 m from the nearest DKIST staging area and more than 400 m from construction site.**
***** Data collected prior to June 30, 2016**

Although no petrels were predated in 2015, an adult petrel was predated on June 16, 2016, 26 m inside the conservation fence border nearest to the Kula Forest Reserve and Kahikinui Forest Reserve. This suggests that even with intensive predator control, predators can still occasionally ingress into the border area from unmanaged areas. The agencies might consider encouraging land owners/managers surrounding DKIST Conservation Area to implement comprehensive predator control programs or buffer zones with predator control programs.

Figure 13 demonstrates the effect of the conservation fence and predator control grid implemented in 2013 and completed in early 2014 in the Conservation Area; the predation events recorded were reduced from 7 in 2011 to zero in 2015 (Table 6). The effect was most noticeable below 9,400 ft. elevation.

Figure 13. Density of Hawaiian Petrel Predation/Burrow Trampling Recorded at Different Elevations in DKIST Conservation Area from 2011 to 2015 Near the Summit of Haleakala, Maui



Further, in order to understand whether DKIST construction activities resulted in the decline of active Hawaiian Petrel burrow numbers, the trend of active burrow numbers adjacent to the DKIST construction site was examined (Figure 14). The number of active petrel burrows actually increased in this area, even in years when the overall number of active petrel burrows was declining (2011-2013 & 2015). It appears that DKIST construction activities have some as yet not understood benefit to attract petrels to breed in this area. While it is too soon to definitively correlate the effects of the rodent control grid with the large number of successful burrows and nesting success rate (Figure 15), Seven seasons of zero rodent captures during rodent population monitoring (Table 2) might be indicative of the positive effect.

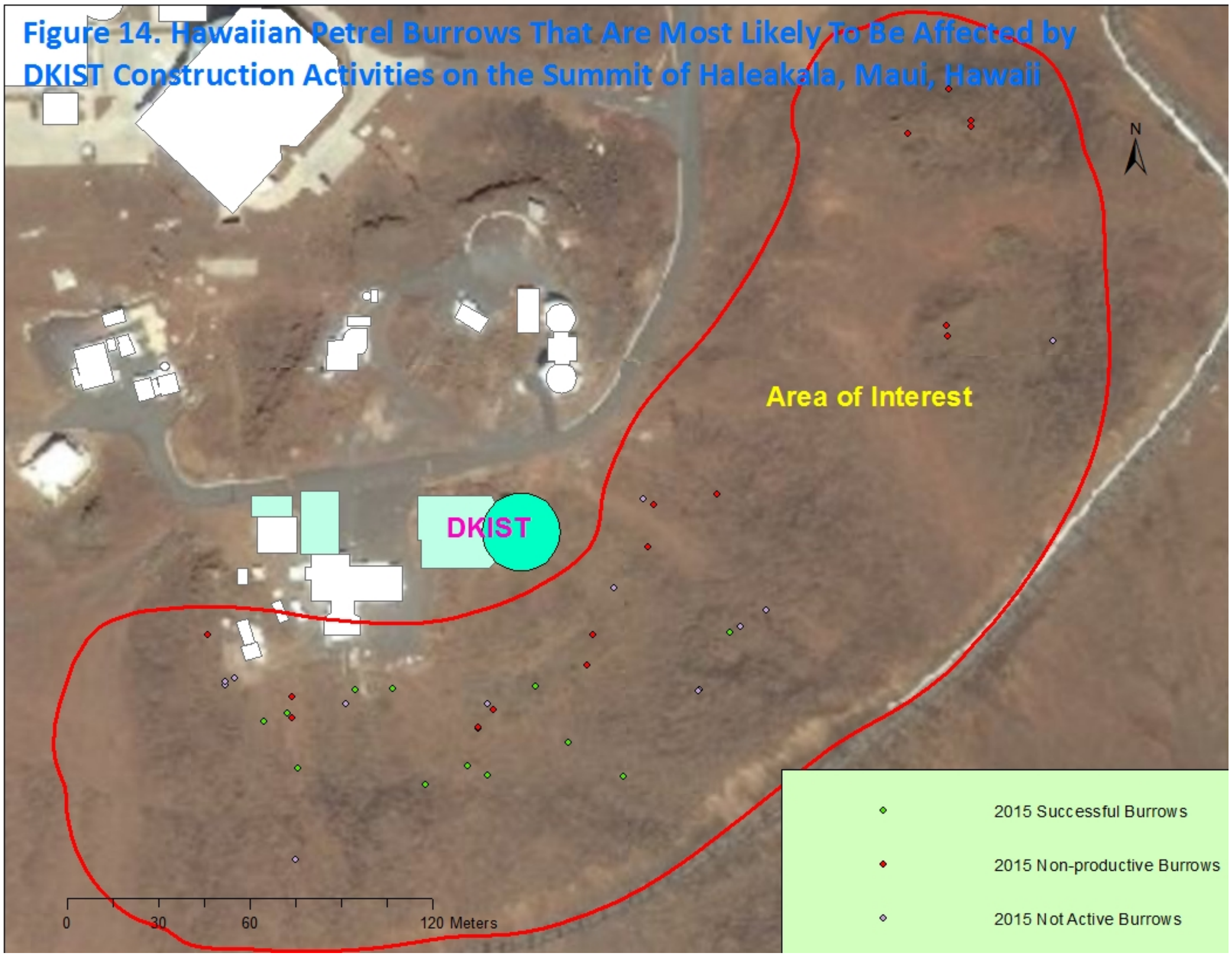


Figure 14. Hawaiian Petrel Burrows That Are Most Likely To Be Affected by DKIST Construction Activities on the Summit of Haleakala, Maui, Hawaii

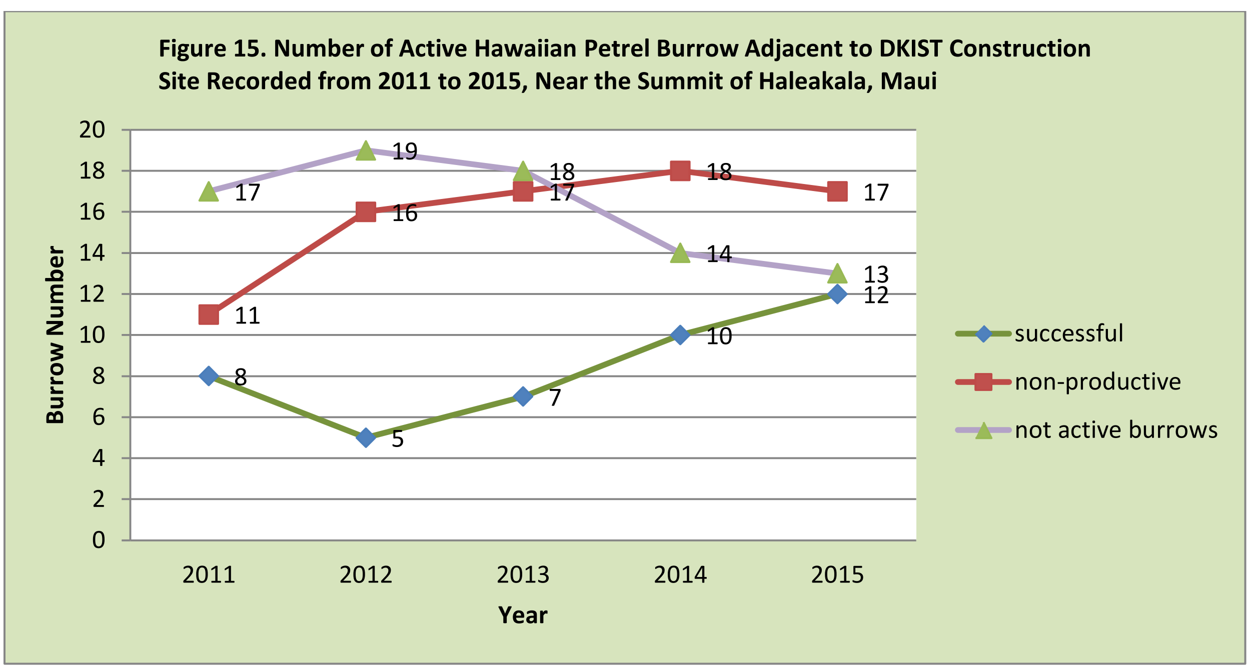


Figure 15. Number of Active Hawaiian Petrel Burrow Adjacent to DKIST Construction Site Recorded from 2011 to 2015, Near the Summit of Haleakala, Maui

Based on the trend of reduced predation events (which was assumed to help increase the active burrow number; Table 6 and Figure 13), an increase in the active burrows adjacent to the DKIST site from 2011 to 2015 (Figure 15), and the fact that DKIST construction did not begin until December of 2012, it seems highly unlikely that the decrease noted in overall active burrow numbers from 2011 to 2013 (Figure 8) were related in any way to construction activities.. The initial decline of active petrel burrows recorded in the larger DKIST HCP/BO monitoring area probably resulted from causes external to the breeding colonies and/or during the nonbreeding season, when the petrels were travelling on the open ocean, and not while the petrels were in the breeding colonies.

The data discussed in the sections above suggest some conclusions:

1. a reduced predation event density nearest to the DKIST construction site before and after construction began may have been the result of relatively high human activity intensity at the summit area, which may have reduced predator activities or predation frequency.

2. although not statistically significant due to a small sample size, a trend of reduced predation/trampling was detected in both the Conservation Area and Control Site.

3. the implementation of the DKIST HCP conservation fence and predator control grid has greatly reduced the number of predation and trampling events in the predator impacted lower portion of the Conservation Area, even though no feral cats or mongooses were trapped.

4. DKIST construction seemed to attract additional breeding petrels to nests and the dense rodent control grid installed in this area seemed to benefit petrel reproductive success.

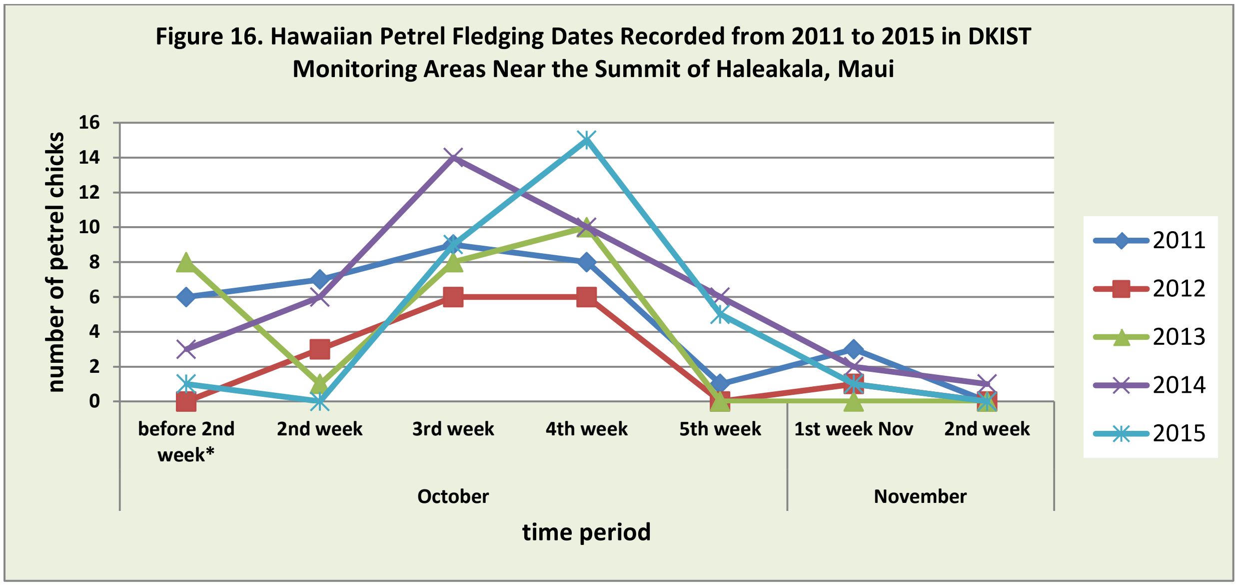
5. the type of petrel collision with DKIST construction structures of most concern to biologists prior to construction hasn't been observed since construction began in December of 2012. As the external construction activity nears its completion, the probability of such events will further diminish.

6. Due to the life history and home range of the Hawaiian Petrel, there are still variables that impact petrel mortality and reproductive performance that cannot be controlled or even influenced by DKIST HCP/BO conservation efforts. These include global weather changes, over- fishing of apex predator fish, plastic particles suspended in the marine ecosystem, etc. However Conservation efforts implemented under the DKIST HCP and BO are more likely to reduce predation effects that influence mortality and reproductive performance while petrels are present in the Conservation Area.

VI D. Fledgling Dates

Historical Data: During the three years of his study Simon (1985) reported that the Hawaiian Petrel fledging period extends from 8 October to 30 October. The median fledging date was 23 October 1979 (±6.5 days), 19 October 1980 (±6.7 days), and 19 October 1981 (±6.1 days). To investigate the potential impacts of DKIST construction on fledgling dates, the resource management team has monitored chicks' first appearance outside active burrows and fledgling departures since 2011. Since the number of active burrows varies from year to year, the number of burrows being monitored by cameras also varies from year to year.

Project Data: Figure 16 presents the overall fledging departure dates from 2011-2015 in weekly intervals.



2011 -2014

- In 2011, 8 of the 17 burrows being monitored by cable connected surveillance cameras were successful. Based on the video recordings of the eight successful burrows around the Mees Observatory, the earliest fledging date was on October 19 and the latest date was October 25 (median date: October 22).

- In 2012, 6 of the 18 burrows being monitored by cameras were successful. Based on the video recordings of the six successful burrows around the Mees Observatory, the earliest fledging date was on October 12 and the latest date was on October 19 (median date October 17).

- In 2013, 7 of the 19 burrows being monitored by cameras were successful in fledging petrels. We also placed 16 camera traps at active burrow sites outside of the Mees Observatory area. Among these 16 additional camera traps, we recorded fledging dates at 10 burrows. Based on 17 image recordings, the fledging dates were between October 10 and October 24 (median date: October 19).

- In 2014, 10 of the 19 burrows being monitored by cameras were successful in fledging petrels. We also placed 39 camera traps at active burrow sites outside of the Mees Observatory area. Among these camera traps, the exact fledging dates at 25 burrows were recorded. The exact fledging dates at 3 burrows manually monitored were also observed. Based on 38 fledging date recordings, the fledging dates were between September 24 and November 09 (median date: October 17).

2015

In 2015, 11 of the 19 burrows being monitored by cameras were successful in fledging petrels, which is the highest number yet counted. We also installed 35 camera traps at active burrow sites outside of the Mees Observatory area. Among these camera traps, the exact fledging dates at 20 burrows were recorded (including 2 in the Control Site). Based on 31 fledging date recordings, the fledging dates were between September 29 and November 01 (median date: October 22).

The fledging dates collected from 2011 to 2015 were within the range of what Simons (1985) reported, such that no impact on petrel fledging dates from DKIST construction activities could be detected.

Similar to previous years and historical data; the recorded events of 2015 confirmed that Hawaiian Petrels begin fledging from their burrows during the latter part of October as was the case in previous breeding seasons. The 3rd and 4th weeks of October accounted for the largest number of fledged chicks. By the end of the 1st week of November, most chicks had already fledged and left the breeding colony.

2016

Results are pending the end of the petrel nesting season.

VII. Suspension Or Removal of the Following Mitigation Measures

Certain mitigation measures that were originally in the HCP or BO have been reconsidered. After extensive fieldwork, the DKIST resource management team and the supporting agencies have agreed to the following: while Hawaiian Petrel social attraction/artificial burrows can be reinstated, this measure is not currently necessary. Also, due to its infeasibility, landscape scale rodent control has been permanently removed as a required measure.

- *Hawaiian Petrel Social Attraction/Artificial Burrows*

  The purpose of these two measures was to recruit non-breeders into managed vacant areas to compensate for the effects of lack of suitable burrows. However, since 150+ non active burrows have been recorded in the Conservation Area each year, it would seem artificial burrows may not be necessary, since there is already an abundance of unoccupied burrows. Also, 120-160 active breeding pairs exhibiting courtship behavior were recorded in the last four seasons, suggesting that there are more “real petrels” attracting other petrels into a “hospitable habitat” than recordings/decoy birds could accomplish. The other aspect to consider is that predation of live Hawaiian Petrels is still a threat in the Conservation Area, and broadcasting courtship sounds might attract predators into the area. Another concern is that broadcasting petrel sounds might disturb the behavior of the local population. These may be future adaptive management measures to be implemented if Net Recovery Benefit does not meet annual objectives. However, at present it appears that Net Recovery Benefit can be achieved without implementing social attraction/artificial burrows.

- *Landscape Scale Rodent Control*

This landscape scale short term rodent control 50 m grid was required only in the BO. The largest landscape scale rodent control grid in Hawaii is at the 20-ha Ka'ena Point Natural Area Reserve. The world's largest 307-ha Orokonui Ecosanctuary of New Zealand employed aerial broadcasts (which is still illegal in Hawaii). Both sites were equipped with "predator-proof" fences to prevent rodent re-ingress. Without a predator proof fence, rodent re-ingress will be repetitive and negate any landscape rodent control grid.

VIII. Summary of Results

Petrel Collision: The DKIST team did not detect any Hawaiian Petrel collisions with any structures between June 7, 2011 and June 30, 2016, including DKIST-related structures that first appeared on site in December 2012.

Impact on Nesting Activity and Fledgling Success:

- No adverse impacts were statistically detected on Hawaiian Petrel Nesting Activity and percentage of Nesting Success that resulted from DKIST construction activities and conservation measures implemented in the Conservation Area. The Control Site and Conservation Area appear to have a different quality of Hawaiian Petrel breeding habitat such that even before construction began and mitigation measures were in place, burrow density and nesting success rates in the Conservation Area were four to five times higher.
- Thus far, the largest number of both active and highest density of burrows, were recorded in 2015.
- To date, the highest nesting success rate was recorded in 2014.
- The number of active and successful burrows continues to increase adjacent to the DKIST construction site (around Mees Observatory).
- The active and successful burrow density increased at the lower boundary area after the predator grid was installed in 2014.
- All of the above have demonstrated that thus far, DKIST construction activities seem to have no adverse impact on petrel reproductive performance in this area, and in 2014 & 2015 DKIST conservation measures were likely aiding petrels in high predator impact areas in the lower parts of the Conservation Area.

Predation Mortality: It appears that DKIST mitigation measures have helped reduce predation mortality by 100% (from 8 in 2011 to 0 in 2015) within the Conservation Area.

Fledging Dates: No obvious fledging date changes could be detected in the last five years. An extended fledging period in 2014 was recorded; this might be due to higher nesting success observed in the Conservation Area.

Measuring Net Benefit: Both "Nesting Activity Percent" and "Nesting Success Percent" or density of both indexes could be greatly affected by variables that occur outside of petrel breeding colonies, such that conservation measures implemented in breeding colonies can only reliably reduce predation. Since sufficient burrow sites and breeding pairs already exist inside the Conservation Area, predation reduction is probably DKIST's greatest benefit to Hawaiian Petrel population growth thus far. Ultimately, using predation density might be a more objective approach to measuring DKIST Net Recovery Benefit

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